

The heart as a pump

In physiology the heart consider as a pump that means it pump blood throughout the body ,actually there are two separate pumps ,right heart that pumps blood through the lungs and left heart that pumps blood through peripheral organs and each one of these hearts is a two champers pump composed of an atrium and a ventricle ; the atrium functions as a weak primer pump for ventricle , the ventricle in turn supply the main force that propel blood either to pulmonary circulation or systemic circulation .

Physiology of cardiac muscle :

The heart is composed of three major types of muscles : atrial muscle , ventricle muscle ,and a specialized excitatory and conductive muscle fibers . the atrial and ventricular muscle contract in much the same way as skeletal muscle except the duration of contraction is much longer . conversely the specialized excitatory and conductive fibers contract weakly because they contain few contractile fibrils ; instead they exhibit rhythmicity and varying rates of generating and conducting electrical signals for controlling heart beating .

Cardiac muscle as syncytium :

The heart muscle consist of many cardiac muscle cell which have interconnections between them , this connections called (gap junction) and through this there is free diffusion of ions ,so when heart muscle become excited at any point the action potential spread along the whole muscle and the contraction occurs   as a single unit.

The heart actually consists of two syncytiums :

*atrial syncytium that constitutes the walls of the two atria .

*ventricular syncytium constitutes the walls of ventricles the atria are separated from ventricles by fibrous tissue, normally the potentials are not conducted from atria to ventricles directly through this fibrous tissue but they are conducted by specialized conductive system called AV bundle . the division of heart muscle in to two functional syncytium allows the atria to contract a short time ahead of ventricular contraction which is important for effectiveness of heart pumping .

What causes the long action potential and the plateau ?

First ,the action potential of skeletal muscle is caused entirely by sudden opening of large numbers of fast sodium channels they are called like that because they remain open for a short time and then abruptly close and at the end of this closure repolarization occurs so the action potential is spike meaning that repolarization occurs rapidly after depolarization .

But in cardiac muscle the action potential is caused by the opening of two channels:

(1) fast sodium channels.

(2) slow calcium –sodium channels they are called slow channels because they are slow to open and remain open for a long time during opening of these channels a large quantity of both calcium and sodium flow to the interior of the cardiac muscle fibers and this maintain a prolonged period of depolarization causing plateau in the action potential .

Cardiac cycle:

The cardiac events that occurs from the beginning of one heartbeat to the beginning of the next heartbeat

The cardiac cycle consist of a period of relaxation called diastole during which the heart fills with blood followed by a period of contraction called systole

During ventricular systole A-V valves are closed so blood that come from veins to atria and it accumulated in atria, near the end of ventricular systole ventricular pressure reach zero mm/mercury

During ventricular systole the pressure increase to make ejection of blood so in this time blood accumulated in atria and developed pressure so pressure different between atria and ventricle occurs causing opening of A-V valves and rapid flowing of blood from atria to ventricles and that occurs in the first third of diastole period .during the middle third of diastole ,valves are open and blood come from veins to atria to ventricles this period called (diastasis) . during the last third of diastole atrial contraction occurs and additional blood flow from atria to ventricle .

After diastole systole happens , when left ventricle pressure increase above 80 mm/mercury the aortic valve open so blood is pumped to all body ,when right ventricle pressure is increase above 8mm/Hg the pulmonary valve open and blood flow to the lungs .

*End diastolic volume :the amount of blood in each ventricle at the end of diastole and is equal to 120 ml

*End systolic volume : the amount of blood in each ventricle at the end of systole and is equal to 50 ml

*Stroke volume output : the amount of blood pumped in each heartbeat by each ventricle and is equal to 70ml

all of these cases at rest.*note*

Valves of the heart:

There are two types of valves in the heart

*atrioventricular valves (A-V):

1) tricuspid valve   2) mitral valve

*semilunar valve:

1) pulmonary valve   2) aortic valve

Functions of A-V valve :*

Prevent back flow of blood from ventricles to atria during ventricular systole.

*function of semilunar valve:

Prevent back flow of blood from aorta and pulmonary arteries to ventricles during ventricular diastole.

In case of A-V valves there are papillary muscle attached to the cusps of the valve by chordae tendineae ; during ventricular systole (contraction) contraction of these muscle also occurs to pull the cusps of the valve inward toward ventricle to prevent excessive bulging of the cusps outward toward the atria . leakage of blood back ward may happen if there is no papillary muscle , repture of chordea tendineae   happen or in case of paralysis of papillary muscle .

Aortic and pulmonary valves function quit differently from A-V valves first, the high pressure in the arteries at the end of the systole cause these semilunar valve to close and this occurs strongly in contrast to A-V valves

Second , because of smaller opening the velocity of blood ejection through these valves is greater than A-V valves .

Heart sounds

When listening to the heart with a stethoscope we can, not hear the opening of the valves because it is slowly developed process that normally make no noise, however when the valves close the cusps of the valves and surrounding fluids vibrate under the influence of the sudden pressure giving sounds that travel in all direction through the chest.

*First heart sound caused by the closure of A-V valves

*Second heart sound caused by the closure of the semilunar valves.

Regulation of heart pumping (cardiac output)

When a person is at rest the heart pumps only 4-6 liters of blood each minute .during sever exercise the heart may be required to pump four to seven times this amount.

The basic means by which the volume pumped by heart is regulated are 1) intrinsic cardiac regulation of pumping in response to changes in volume of blood flowing in to the heart 2) control of heart rate and strength of heart pumping by autonomic nervous system .

1))intrinsic regulation of cardiac output (frank-starling mechanism)

Frank-starling mechanism means within physiological condition the heart pumps all blood that returns to it by vein

*If there is increase in the venous return it will cause more stretch of the ventricles and more optimal degree of overlapping of actin and myocin will occurs so force of contraction of the heart will increase and the cardiac output will increase.

*if the venous return increase the stretch of right atrium will occurs and that will stimulate the SA node so heart rate will increase and cardiac output will increase.

2)) autonomic nervous system regulation

Heart pumping also controlled by sympathetic and parasympathetic nerves

Sympathetic stimulation increase heart rate ,force of contraction so heart pumping will increase .

Parasympathetic stimulation decrease heart rate, force of contraction so heart pumping.

Effect of potassium ions on heart function

The normal concentration of K ions in ECF is 3.5—5 mm/l ..excess potassium in the extracellular fluid cause the heart to become dilated and slow the heart rate ,cardiac arrest and may death .

These effects result from the fact that a high k concentration in ECF decrease the resting membrane potential in cardiac muscle so the intensity of action potential so the contraction of the heart will be weaker .

هذا عمل طلابي قد لا يخلو من الخطأ فالرجاء أعلامنا في حالة وجود خطأ لتصحيحه ....ولا تنسونا من صالح الدعاء

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